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(12) # EUROPEAN PATENT SPECIFICATION

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(54) **Lead frame with reduced corrosion.**

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(56) References cited :
EP-A- 0 132 596
EP-A- 0 250 146
DE-A- 3 312 713
US-A- 4 141 029
US-A- 4 601 958
PATENT ABSTRACTS OF JAPAN vol. 9, no. 89 (E-309) 18 April 1985 ; & JP-A-59 219 945

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Description

TECHNICAL FIELD OF THE INVENTION

This invention relates to general to integrated circuits, and more particularly to integrated circuit devices having reduced galvanic migration of corrosive products.

BACKGROUND OF THE INVENTION

In the construction of integrated circuit devices, lead frames are used to provide electrical interconnection to a semiconductor circuit. Typically, the base metal of the lead frame is copper because of its high thermal conductivity. Other base metals include stainless steel and Alloy 42, which is an alloy of 42% nickel and 58% iron. In some instances, a nickel layer on the order of 100 microinches (1 microinch = 25.4 nm) is formed over the base metal to prevent temperature driven diffusion of the copper to the surface of the lead frame. Corrosion products formed by copper diffusion, such as copper sulfides and oxides, will degrade the solderability of the lead frame and will reduce the shelf life of the final product.

The nickel layer, however, contains pores through which the corrosion products may migrate. A nickel layer thickness of at least 400 microinches would be needed to reasonably assure that no continous paths through the nickel layer would be available for copper migration. Unfortunately, a thickness of this magnitude will crack when the leads are eventually bent to form the dual inline package (DIP) or surface mount integrated circuit (SMIC).

A layer of palladium (Pd) may be formed over the nickel layer. The palladium top surface may be thermosonically bonded to gold wire, providing a stronger bond than available with a silver lead end. Furthermore, palladium will not tarnish or oxidize in air, thus retaining a clean bonding surface indefinitely. The palladium layer, however, will produce a galvanic potential between the palladium layer and the copper base, drawing copper ions to the surface. This galvanic couple accelerates pore corrosion in the palladium plated lead frame, which results in oxides and sulfides and other reaction products of copper appearing on the lead frame surface. The oxides and sulfides and other corrosion products discolor the surface of the lead frame and degrade its solderability.

Therefore, a need has arisen to provide an integrated circuit lead frame with reduced galvanic potential for preventing surface corrosion.

DE-A-3 312 713 discloses lead frames having various three layer conductive coatings on the base region. The layer next to the base metal region is selected from nickel, cobalt, chromium, palladium and alloys thereof. The middle anti-oxidant layer is selected from tin, cadmium, palladium, ruthenium and alloys thereof. The top layer is silver or a silver alloy.

The Patent Abstracts of Japan, volume 9, no. 89 (E-309), dated 18 April 1985, the abstract of JP-A-59 219 945, discloses a two layer coating for improving the solderability of a lead frame with a stainless steel base region. The layer next to the base region is nickel and the top layer is gold or silver or palladium.

US-A-4 601 958 suggests a broad class of four layer anti-corrosion coatings for iron alloy based sealing lids and lead frames for semiconductor packages. In particular it discloses alternate layers of nickel and gold with the top layer being gold.

EP-A-0 250 146 discloses two layer coatings for a copper based lead frame. The layer next to the base region is nickel and the top layer is palladium or an alloy of palladium and nickel.

SUMMARY OF THE INVENTION

In accordance with the present invention, a lead frame is provided which substantially eliminates or prevents the disadvantages and problems associated with prior lead frames.

The present invention provides a lead frame for an integrated circuit, comprising a plurality of leads, each comprising:

(i) a base metal region including copper or a copper alloy,

(ii) a strike layer of nickel over the base metal region,

(iii) a layer of a palladium/nickel alloy over the strike layer,

(iv) an intermediate layer of nickel over the palladium/nickel alloy layer, and

(v) a top layer of palladium over the intermediate layer,

the palladium/nickel alloy layer preventing ions from the base layer migrating to the top layer under the force of a galvanic potential.

The lead frame of the present invention provides a palladium plated lead frame which may be used with a copper base metal, without contamination of the top surface due to a galvanic potential between the palladium top surface and the base metal. The palladium/nickel alloy layer separates the base metal from the nickel intermediate layer which is used to prevent thermal diffusion of the base metal atoms to the upper surface. The palladium/nickel alloy layer minimizes the galvanic potential across the nickel intermediate layer, thereby preventing migration of the base metal ions to the top surface. Corrosion products formed in the palladium/nickel alloy layer due to the potential between the palladium/nickel alloy layer and the base metal will be neutral and insoluble; therefore, they will not migrate through the nickel intermediate to the top surface.

This aspect of the present invention provides the

technical advantage of a palladium plated lead frame which is not subject to corrosion due to galvanic potential forces aiding the migration of the base metal ions to the top surface where they will form corrosion products.

In another aspect of the present invention the nickel strike layer prevents contamination of the palladium/nickel bath used to form the palladium/nickel alloy layer. The nickel strike in conjunction with the palladium/nickel layer also provides the technical advantage of reducing the porosity of the material between the base metal and the palladium top layer, thereby minimizing the paths through which a base metal ion could migrate.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and the advantages thereof, reference is now made to the following description now taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a top plan view of a lead frame;

FIGURE 2 is a cross-sectional side view of a prior art lead frame;

FIGURE 3 is a cross-sectional view of the lead frame of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The preferred embodiment of the present invention is best understood by referring to FIGUREs 1-3 of the drawings, like numerals being used for like and corresponding parts of the various drawings.

FIGURE 1 illustrates a top view of a typical lead frame 10 used to support a semiconductor circuit 12. The lead frame 10 comprises a platform 14 on which the semiconductor circuit 12 is bonded. The semiconductor circuit 12 is connected to the external leads 16 using fine wire 18, typically made of gold. Dam bars 20 connect the external leads 16, but are subsequently trimmed away after a packaging medium has been applied. As shown in FIGURE 1, lead frames 10 are typically connected to each other by connecting strips 22 for mass production.

FIGURE 2 illustrates a cross-sectional view of a prior art lead frame 24 enclosed in packaging material 26. The platform 14 and external leads 16 are shown as comprised of a base metal 28 enclosed in a intermediate layer 30 which is covered by a top layer 32. Typically, the base metal 28 comprises copper, the intermediate layer 30 comprises nickel and the top layer 32 comprises palladium. The gold wires 18 may be connected directly to the palladium top layer 32 without the need for a silver coating.

Assuming a top layer 32 of palladium (Pd) and a base metal 28 of copper (Cu), a galvanic potential will exist between the top layer 32 and the base metal 28 due to the differences in their respective standard reduction potentials. A galvanic cell is thus created, with the nickel intermediate layer acting as the electrolyte. The galvanic potential will draw copper ions through the pores of the nickel layer to the top layer 32. Hence, the copper ions will be pulled to the palladium top layer 32, through the nickel intermediate layer 30, accelerating pore corrosion in the palladium top layer 32. Consequently, oxides and sulfides and other reaction products of copper may form on the surface of the top layer 32, causing discoloration of the surface and degrading its solderability.

FIGURE 3 illustrates the lead frame 34 of the present invention. The base metal 28, including copper or a copper alloy, is covered by a strike layer 36 of nickel. The nickel strike layer 36 is covered by a palladium/nickel alloy layer 38. The alloy layer 38 is covered by a intermediate layer 40 of nickel. The intermediate layer 40 is covered by a top layer 42 of palladium.

The nickel strike layer 36 formed over the base metal is provided to prevent contamination of the subsequent palladium/nickel bath which is used to form the alloy layer 38. The nickel strike layer 36 also helps to minimize the number of pores through which a path can be formed in the intermediate layer 40. Typically, the nickel strike layer 36 has a thickness of less than 5 microinches.

The palladium/nickel alloy layer 38 typically has a thickness of less than 3 microinches. The purpose of the palladium/nickel alloy layer 38 is to decouple the galvanic potential between the copper base metal 28 and the palladium top layer 42. By virtue of the palladium/nickel alloy layer 38, the potential across the nickel layer 40 is reduced substantially to zero, since the galvanic potential of the palladium top layer 42 is the same as the galvanic potential of the palladium/nickel alloy. Therefore, the present invention provides the technical advantage of preventing migration of base metal ions to the top layer under the force of a galvanic potential.

However, it is possible that corrosion products may form under the palladium/nickel alloy layer 38, due to the galvanic potential between the palladium/nickel alloy layer 38 and the copper base metal 28. Thus, it is possible that copper sulfide or copper chloride or other reaction products may form on the palladium/nickel alloy layer 38; however, these compounds are electrically neutral and insoluble, and are therefore unlikely to diffuse through the nickel intermediate layer 40.

In addition to reducing the galvanic potential, the nickel strike layer 36 and palladium/nickel alloy layer 38 decrease the porosity of the intermediate nickel layer 40. The decreased porosity provides the technical advantage of further reducing the possibility of a contaminant reaching the top layer 42.

Because of the decreased porosity and de-

creased galvanic potential, a thinner nickel intermediate layer 40 may be used without fear of copper ion migration.

Claims

1. A lead frame for an integrated circuit, comprising a plurality of leads, each comprising:
   (i) a base metal region (28) including copper or a copper alloy,
   (ii) a strike layer (36) of nickel over the base metal region,
   (iii) a layer (38) of a palladium/nickel alloy over the strike layer,
   (iv) an intermediate layer (40) of nickel over the palladium/nickel alloy layer, and
   (v) a top layer (42) of palladium over the intermediate layer,
   the palladium/nickel alloy layer (38) preventing ions from the base layer migrating to the top layer (42) under the force of a galvanic potential.

2. A lead frame according to claim 1 wherein the strike layer (36) has a thickness of less than 127 nm (5 microinches).

3. A lead frame according to claim 1 or claim 2 wherein the palladium/nickel alloy layer (38) has a thickness of less than 76 nm (3 microinches).

4. A method of forming a lead frame according to any one of claims 1 to 3, wherein the palladium/nickel alloy layer (38) is formed in a palladium/nickel bath, the strike layer (36) preventing contamination of the bath with copper.

Patentansprüche

1. Leiterrahmen für eine integrierte Schaltung, mit mehreren Anschlüssen, die jeweils enthalten:
   (i) einen Basismetallbereich (28), der Kupfer oder eine Kupferlegierung enthält;
   (ii) eine Blockierschicht (36) aus Nickel auf dem Basismetallbereich;
   (iii) eine Schicht (38) aus einer Palladium-/Nickel-Legierung auf der Blockierschicht;
   (iv) eine Zwischenschicht (40) aus Nickel auf der Palladium/Nickel-Legierungsschicht;
   (v) eine obere Schicht (42) aus Palladium auf der Zwischenschicht;
   wobei die Palladium/Nickel-Legierungsschicht (38) verhindert, daß Ionen von der Basisschicht aufgrund der Kraft eines galvanischen Potentials zu der oberen Schicht (42) wandern.

2. Leiterrahmen nach Anspruch 1, bei dem die Blockierschicht (36) eine Dicke von weniger als 127 nm (5 Mikroinch) aufweist.

3. Leiterrahmen nach Anspruch 1 oder Anspruch 2, bei dem die Palladium/Nickel-Legierungsschicht (36) eine Dicke von weniger als 76 nm (3 Mikroinch) aufweist.

4. Verfahren zum Bilden eines Leiterrahmens nach einem der Ansprüche 1 bis 3, bei dem die Palladium/Nickel-Legierungsschicht (38) in einem Palladium/Nickel-Bad gebildet wird, wobei die Blockierschicht (36) ein Verunreinigen des Bades mit Kupfer verhindert.

Revendications

1. Cadre conducteur pour un circuit intégré, comprenant une pluralité de conducteurs, comprenant chacun:
   (i) une région (28) en métal de base comportant du cuivre ou un alliage de cuivre,
   (ii) une couche de dépôt (36) en nickel sur la région en métal de base,
   (iii) une couche (38) en alliage de palladium/nickel sur la couche de dépôt,
   (iv) une couche intermédiaire (40) en nickel sur la couche en alliage de palladium/nickel, et
   (v) une couche supérieure (42) en palladium sur la couche intermédiaire,
   la couche (38) en alliage de palladium/nickel empêchant les ions en provenance de la couche de base de migrer vers la couche supérieure (42) sous l'effet de la force d'un potentiel galvanique.

2. Cadre conducteur selon la revendication 1, dans lequel la couche de dépôt (36) a une épaisseur inférieure à 127 nm (5 micro-pouces).

3. Cadre conducteur selon la revendication 1 ou la revendication 2, dans lequel la couche (38) en alliage de palladium/nickel a une épaisseur inférieure à 76 nm (3 micro-pouces).

4. Procédé de formation d'un cadre conducteur selon l'une quelconque des revendications 1 à 3, dans lequel la couche (38) en alliage de palladium/nickel est formée dans un bain de palladium/nickel, la couche de dépôt (36) empêchant la contamination du bain par du cuivre.

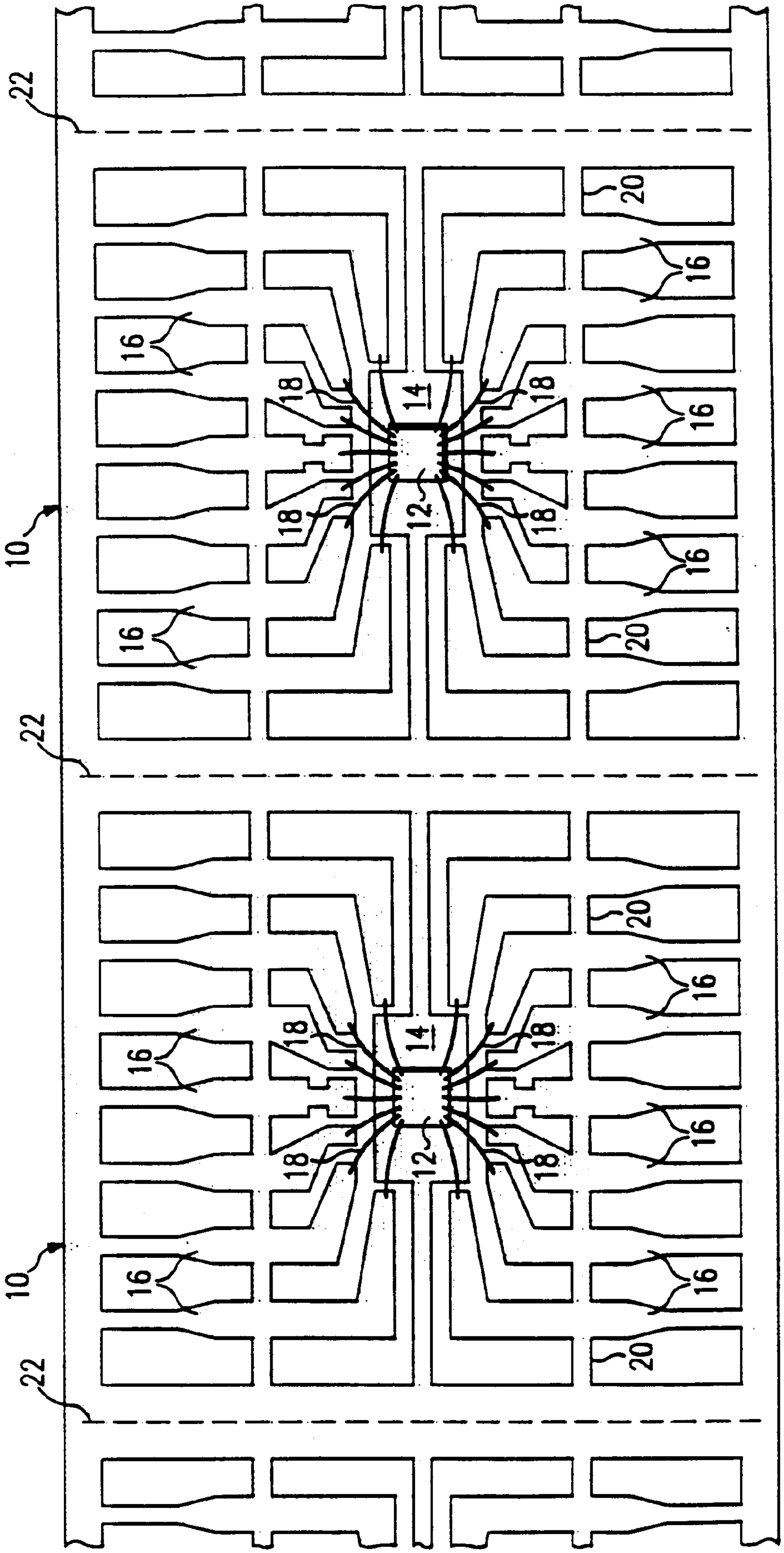

FIG. 1

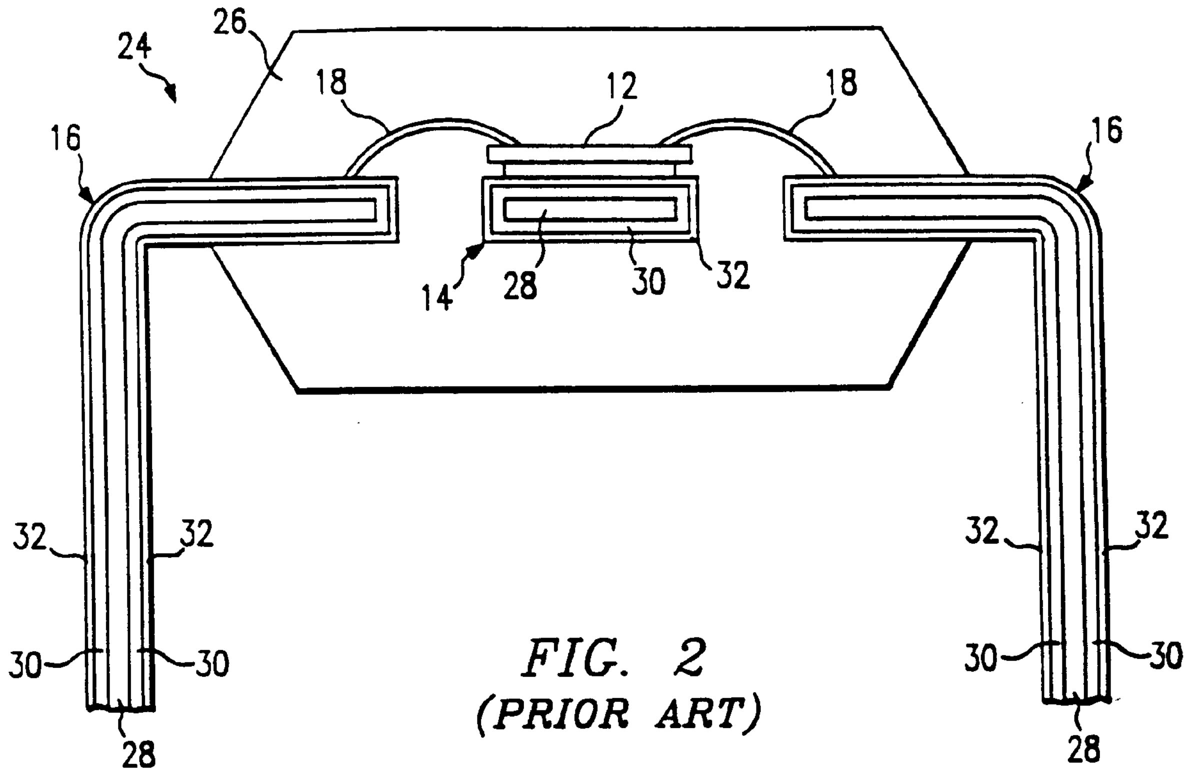

FIG. 2
(PRIOR ART)

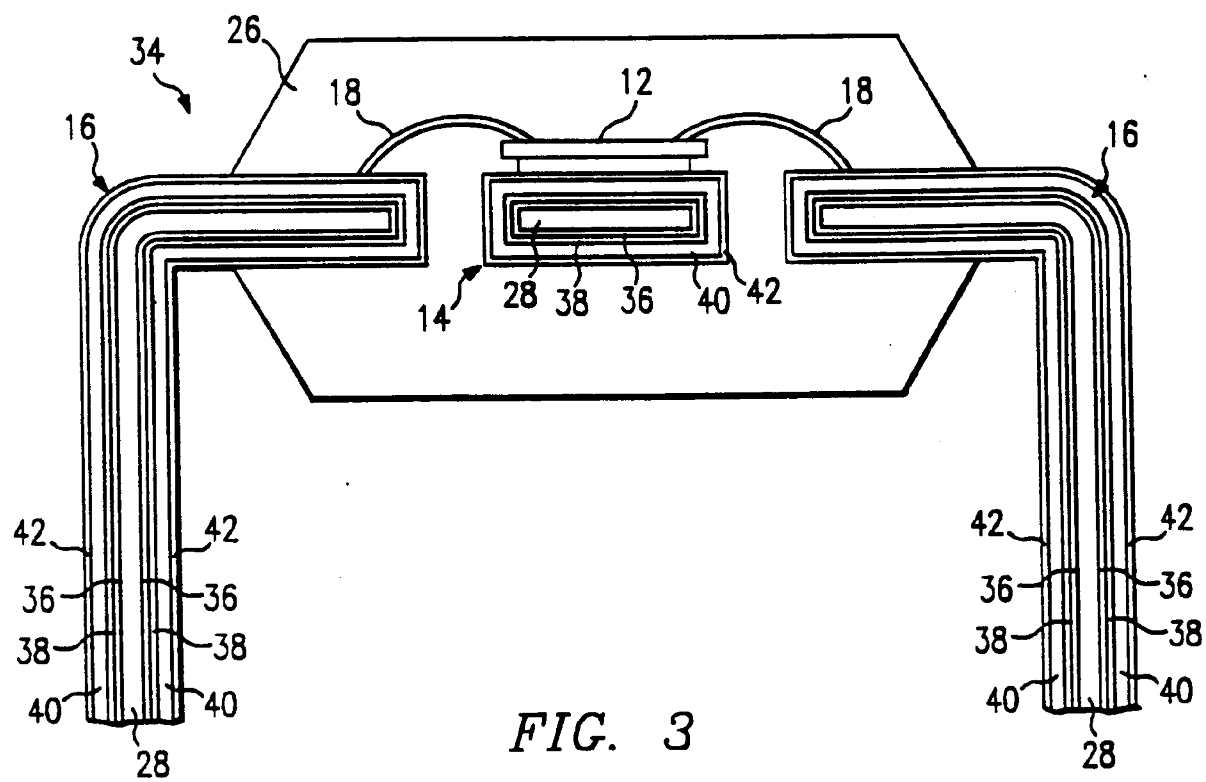

FIG. 3